Amendments to the Claims

This listing of claims will replace all prior versions and listing of claims in the application.

Listing of claims.

1. (Currently Amended) An assembly comprising:

an actuator with a longitudinal axis having a fixed end, and a free end configured to translate in three orthogonal directions with respect to said fixed end;

a multiple bar linkage having first and second links mutually constrained to translate with respect to each other, and wherein said first link is fixed to a reference structure and said second link is constrained to translate in a direction generally parallel to the longitudinal axis of said actuator; ~~and~~

a sample holder supported by said linkage; and

a coupling having first and second ends, said first end being fixed to said actuator proximate to its free end, and said second end being fixed to said second link, the coupling adapted to transmit displacement in a direction substantially parallel to the longitudinal axis of said actuator.

2. (Original) The assembly of claim 1, wherein said actuator has a z-axis translating section, and an x and y-axis translating section disposed between said fixed end and said z-axis translating section.

3. (Currently Amended) The assembly of claim 2, wherein said reference structure is mechanically independent from translation of said z-axis translating section, but mechanically responsive to said x and y-axis translating section.

4. (Original) The assembly of claim 3, wherein said reference structure is fixed to said multiple bar linkage to deflect said multiple bar linkage in X and Y directions in response to X and Y deflections of said x and y-axis translating stage.

5. (Original) The assembly of claim 4, wherein said multiple bar ~~-bar-~~ linkage further includes a first mirror fixed to at least one of said links of the multiple~~-~~bar linkage,

and a second mirror fixed to another of said links of said multiple-bar linkage.

6. (Original) The assembly of claim 5, wherein the assembly is adapted to be supported in a chassis, and further wherein said first mirror is disposed in the path of a light beam from a light source mounted on said chassis and is disposed to reflect the light toward said second mirror.

7. (Currently Amended) The assembly of claim 1, wherein the assembly ~~metrology apparatus~~ is a scanning probe microscope.

8. (Original) The assembly of claim 1, wherein said actuator is a piezoelectric actuator.

9. (Currently Amended) In an assembly for a metrology apparatus having a probe assembly, the assembly including an elongate actuator with a longitudinal axis and having a first end configured to be coupled to a frame of the microscope and a free end configured to be coupled to a sample holder, wherein the elongate actuator is configured to provide controllable translation in three orthogonal directions upon application of proper electrical stimuli, a method of reducing positioning errors at the free end of the elongate actuator comprising the steps of:

fixing the probe assembly to the frame;

supporting the sample holder with a reference structure of the metrology apparatus, the reference structure being substantially insensitive to longitudinal expansion or contraction of a first portion of the elongate actuator;

isolating the reference structure from a longitudinal deflection of the first portion of the elongate actuator;

driving the first portion of the elongate actuator;

simultaneously generating both longitudinal deflections as well as lateral deflections in the first portion as a result of said driving step; and

preventing the lateral deflections generated in the first portion of the elongate actuator from laterally deflecting the sample holder while simultaneously transmitting the

longitudinal deflections to the sample holder.

10. (Original) The method of claim 9, wherein a second portion of the actuator is configured to provide translation in a plane substantially perpendicular to the longitudinal direction, and wherein the method further includes the steps of:

driving the second portion of the actuator;

generating lateral deflections in the second portion as a result of said driving the second portion step; and

transmitting the lateral deflections in the second portion to the sample holder.

11. (Currently Amended) A scanning probe microscope assembly, comprising:

a microscope frame;

a piezoelectric actuator having a first end fixed to said frame and a second free end coupled to a sample holder via a multiple bar linkage that facilitates moving said sample holder substantially only in an intended direction of motion of said actuator;

a first reflector assembly fixed proximate to said free end of said piezoelectric actuator;

a first electromagnetic radiation source fixed with respect to said frame and disposed to direct radiation onto said first reflector assembly; and

a first electromagnetic radiation detector disposed to receive light from said first source after it has been received and reflected by said first reflector assembly and to generate a signal indicative of a degree of longitudinal deflection of said piezoelectric actuator.

12. (Original) The scanning probe microscope assembly of claim 11, further comprising a cantilevered probe having a free end and a fixed end and coupled at its fixed end to said frame,

said probe including a second reflector disposed to translate with said probe when said probe is deflected with respect to said piezoelectric actuator.

13. (Original) The scanning probe microscope assembly of claim 12, further comprising a second electromagnetic radiation detector disposed to receive light reflected from said second reflector and to generate a signal indicative of a degree of deflection of said free end of said probe with respect to said fixed end of the probe.

14. (Cancelled)

15. An apparatus for measuring movement of an actuator in a metrology apparatus, the measuring apparatus comprising:

a sample holder coupled to the actuator;

an optical measuring device including a light source that generates a light beam, said measuring device being configured to change the direction of said beam in response to movement of the actuator;

a sensor to detect said beam and generate a signal indicative of the movement of the actuator; and

~~The apparatus of claim 14~~, wherein said measuring device includes a movable bar assembly coupled to the actuator and to a reference structure, wherein said bar assembly has a reflecting surface that is adapted to deflect said beam, and wherein said bar assembly is responsive to movement of the actuator so as to change the direction of said deflected beam.

16. (Original) The apparatus of claim 15, wherein said bar assembly includes a first link having a first end coupled to the actuator, and a second link defining said reflecting surface and having a first opposed end rotatably coupled to said first link and a second opposed end rotatably attached to said reference structure.

17. (Original) The apparatus of claim 15, wherein said reference structure is tubular and generally surrounds the actuator.

18. (Original) The apparatus of claim 17, wherein said reference structure is configured to allow said light beam to pass therethrough.

19. (Original) The apparatus of claim 15, wherein said bar assembly includes a link having opposed ends, a first opposed end rotatably coupled to the actuator and a second

opposed end rotatably coupled to said reference structure.

20. (Original) The apparatus of claim 15, wherein said bar assembly comprises a four bar linkage including first and second reflecting surfaces, said surfaces disposed to reflect light such that the incoming and outgoing beams are generally parallel.

21. The apparatus of claim 145, wherein said optical measuring device includes a lens disposed intermediate said light source and said sensor.

22. (Original) The apparatus of claim 21, wherein said lens has a magnification equal to 1 + i/o, wherein "i" equals the orthogonal distance between said lens and said sensor, and "o" equals the orthogonal distance between said lens and said light source.

23. (Currently Amended) The apparatus of claim 21, wherein said light source is ~~mounted~~ coupled to the actuator.

24. (Original) The apparatus of claim 23, wherein said lens has a magnification equal to i/o, wherein "i" equals the orthogonal distance between said lens and said sensor, and "o" equals the orthogonal distance between said lens and said light source.

25. (Original) A method for measuring movement of an actuator in a metrology apparatus, the method comprising:

providing a movable bar assembly coupled to the actuator and to a reference structure;

supporting a sample holder with the movable bar assembly; and

measuring, in response to movement of the actuator, movement of said movable bar assembly, wherein the movement of said movable bar assembly is indicative of movement of the actuator.

26. (Currently Amended) The method of claim 25, wherein said movable bar assembly includes a first link having a first end coupled to the actuator, and a second link defining ~~said~~ a reflecting surface and having a first opposed end rotatably coupled to said first link and a second opposed end rotatably attached to said reference structure.

27. (Original) In a metrology apparatus having an actuator for moving a sample in a particular direction, a reference assembly that generally decouples movement of the apparatus in a direction other than the particular direction from the sample, the reference assembly comprising:

a reference structure;

a sample holder coupled to said reference structure and to the actuator, the sample being attached to said sample holder; and

a flexible bar having opposed ends, one of which is coupled to the actuator and the other of which is coupled to said sample holder via a movement isolating device, wherein said flexible bar and said reference structure, are adapted to collectively decouple movement of the actuator in the direction other than the particular direction from the sample.

28. (Currently Amended) The apparatus of claim 27, wherein said reference structure is a tubular frame and has a longitudinal axis that is generally collinear with ~~the~~ a longitudinal axis of the actuator.

29. (Original) The apparatus of claim 27, wherein said flexible bar is more flexible in response to displacements applied thereto in any direction other than the particular direction.

30. (Original) The apparatus according to claim 29, wherein the particular direction is the Z direction.

31. (Original) The apparatus according to claim 27, wherein said movement isolating device is a parallelogram flexure.

32. (Currently Amended) The apparatus of claim 31, ~~wherein said comprising~~ a probe structure assembly comprisesing a four bar linkage having four joints.

33. (Original) The apparatus of claim 27, wherein said movement isolating device is a flexible disc, said flexible disc being attached to said reference structure generally around a perimeter of said flexible disc.

34. (Original) A metrology apparatus for analyzing a sample, the assembly comprising:

an actuator including a first actuator stage configured to controllably move in first and second orthogonal directions, and a second actuator stage adjacent to the first actuator stage and configured to controllably move in a third direction orthogonal to the first and second orthogonal directions;

a reference structure having first and second ends wherein the first end is fixed relative to movement of the second actuator stage;

a coupling coupled to the second actuator stage and to a multi-bar linkage assembly fixed to the second end of the reference structure, wherein the second actuator stage and the coupling are configured to move the linkage in the third orthogonal direction in a manner that substantially isolates the linkage from any second actuator stage motion in the first and second directions;

an objective fixed to the reference structure, wherein the objective is between a light source and a position sensor, and the position sensor measures first actuator stage motion in the first and second directions; and

wherein the multi-bar linkage supports the sample.

35. (Original) The assembly of claim 34, wherein first actuator stage motion in the first and second directions is coupled to the reference structure.

36. (Original) The assembly of claim 35, wherein motion of the reference structure in the first and second directions is translated to the objective.

37. (Original) The assembly of claim 36, wherein the light source and the position sensor are stationary.

38. (Original) The assembly of claim 34, wherein the position sensor is a lateral effect photodiode.

39. (Original) The assembly of claim 34, wherein the objective further comprises a set of microlenses.

40. (Original) The assembly of claim 39, wherein the set of microlenses provide optical magnification to increase a signal-to-noise ratio.

41. (Original) The assembly of claim 40, wherein the magnification is

$$M = 1 + i/o$$

wherein i is an orthogonal distance from the set of microlenses to the position sensor and o is an orthogonal distance from the set of microlenses to the light source.

42. (Original) The assembly of claim 34, wherein the reference structure and the coupling provide a rigid mechanical connection between the first actuator stage and the sample in the first and second directions.

43. (Original) The assembly of claim 34, wherein the reference structure further comprises an inside surface adjacent to the actuator and an outside surface.

44. (Original) The assembly of claim 43, wherein the objective is mounted on the outside surface of the reference structure.

45. (Original) An assembly comprising:

an actuator with a longitudinal axis having a fixed end and a free end configured to translate a sample coupled thereto in three orthogonal directions with respect to the fixed end;

a multiple bar linkage having first and second links mutually constrained to translate with respect to each other, and wherein the first link is fixed to a reference structure and the second link is constrained to translate in a direction generally parallel to the longitudinal axis of the actuator;

a coupling having first and second ends, the first end being fixed to the actuator proximate to its free end, and the second end being fixed to the second link, the coupling adapted to transmit displacement in a direction substantially parallel to the longitudinal axis of the actuator; and

an objective fixed to the reference structure, wherein the objective is between a light source and a position sensor, and the position sensor measures displacement of the

objective in a direction generally perpendicular to the longitudinal axis of the actuator.

46. (Currently Amended) An optical apparatus for measuring movement of an actuator in a metrology apparatus, the optical measuring apparatus comprising:

an objective fixed to a reference structure coupled to the actuator;

a light source that generates a light beam, wherein the optical measuring apparatus changes the direction of the beam in response to movement of the objective;

a position sensor that detects the beam and generates a displacement signal indicative of movement of the actuator in a direction generally perpendicular to a longitudinal axis of the actuator; ~~and~~

wherein a sample is coupled to the actuator; and

and wherein said reference structure moves in the direction generally perpendicular to the longitudinal axis of the actuator.

47. (Currently Amended) A method for measuring movement of an actuator in a metrology apparatus, the method comprising:

providing an objective mounted on a reference structure coupled to the actuator;

measuring movement of the objective, wherein movement of the objective is indicative of movement of the actuator in a direction generally perpendicular to the longitudinal axis of the actuator; and

wherein a sample is coupled to the actuator via a multiple bar linkage so that movement of the actuator in the direction when the actuator is excited to move in a direction coincident with the longitudinal axis of the actuator is substantially decoupled from the sample.

48. (Original) The method of claim 47, wherein the measuring step further comprises:

generating a light beam from a stationary light source;

changing the direction of the beam in response to movement of the objective;

detecting the location of the beam with a position sensor; and

generating a displacement signal indicative of movement of the actuator